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# Human Capital and Macro-Economic Development: A Review of the Evidence\*

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## Abstract

The role of human capital in facilitating macro-economic development is at the center of both academic and policy debates. Through the lens of a simple aggregate production function, human capital might increase output per capita by directly entering in the production process, incentivising the accumulation of complementary inputs and facilitating the adoption of new technologies. This paper discusses the advantages and limitations of three approaches that have been used to evaluate the empirical importance of these channels: cross-country regressions, development accounting and quantitative models. The key findings in the literature are reviewed, and some of them are replicated using updated data. The bulk of the evidence suggests that human capital is an important determinant of cross-country income gaps, especially when its measurement is broadened to go beyond simple proxies of educational attainment. The paper concludes by highlighting policy implications and promising avenues for future work.

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# 1. Introduction

Does human capital contribute to economic development? If so, how much, and through which channels? Different declinations of these questions have played a central role in the macro-development literature of the last few decades. Credible answers are needed to inform several policy debates. At a broad level, the degree to which gaps in human capital, as opposed to other factors of production and technology, explain cross-country differences in income per capita is informative on the extent to which growth-promoting policies should focus on education and skill formation. Moreover, understanding which dimensions of human capital are particularly lacking in developing countries and why is necessary to guide the formulation of concrete policy interventions.

This paper discusses the academic literature on the links between human capital accumulation and aggregate economic performance. It considers several methodological approaches that have been used to analyse different aspects of this complex relationship: cross-country regressions, development accounting and quantitative models. Rather than offering an exhaustive list of all papers in these areas, its main focus is on a general discussion of the underlying assumptions, advantages and limitations of these approaches for evaluating the role of human capital, as well as of the broad insights that have emerged in several decades of research. Moreover, some of the key results are replicated and illustrated using recent data.

A significant part of the debate concerns the measurement of human capital. Traditionally, economists have concentrated on years of schooling and other measures of educational attainment. However, several pieces of evidence suggest that this focus on schooling quantity misses important dimensions of the variation in human capital, both at the individual and the aggregate levels. As a consequence, recent work gives a more central role to schooling quality on one hand, and to additional dimensions such as health and skills accumulated outside of the schooling system on the other.

Across countries, observable proxies for human capital are strongly correlated with mea-

asures of aggregate economic performance, explaining the prominence of this theme in the development debate. Figure 1 shows average years of schooling completed in the working-age population against log GDP per worker in 2010. There is a positively sloped relationship, and the cross-country gaps in educational achievement appear large. A similar pattern emerges when focusing on a direct measure of cognitive skills, the average performance in standardized tests (Figure 2), or on a proxy for the health status of the population, the survival rate to age 65 (Figure 3).<sup>1</sup>

While suggestive, these correlations are not necessarily informative on the role of human capital for economic development. On one hand, the relationship might not be causal in nature, as third factors might explain cross-country differences in both human capital and GDP per worker, and the latter might also explain the accumulation of the former. Moreover, several dimensions of human skills are inherently difficult to measure, and the proxies considered here might miss an important part of the picture. Finally, even a positive and causal relationship between average human capital and development would not be fully informative on the specific channels through which skills contribute to the production process and to differences in economic performance.

The approaches reviewed in this paper attempt to overcome these problems through different strategies. As a background for the discussion of these methodologies, section 2 introduces a simple production function framework which highlights how human capital can affect aggregate economic performance. Section 3 then turns to the discussion of the cross-country regressions approach, which consists of relating measures of economic performance and human capital in a regression model. The well-known econometric difficulties associated to this approach are reviewed, and recent contributions that attempt to overcome them by using instrumental variables, focusing on sub-national settings and other strategies are illustrated. Section 4 discusses development accounting, a methodology based on the direct calibration of an aggregate production function (rather than its estimation). To illustrate the implications of various approaches to account for human capital, the paper replicates and

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<sup>1</sup>The sources and construction of these variables are discussed below.

compares some of the recent results in the literature, using a common sample of countries and data from 2010. Section 5 reviews some of the key results from the calibration of quantitative models on the accumulation and allocation of human capital, and illustrates how this structural approach, while obviously reliant on a specific theoretical structure, can provide useful insights on the various channels through which human capital shapes the production process.

The consideration of this diverse set of approaches leads to some general lessons. First, while the level of educational attainment differs markedly across countries, its quantitative contribution for cross-country gaps in economic performance is limited; in other words, rich countries are not richer (primarily) because workers there spent more years in school. Second, the variation in human capital across countries is much larger than what suggested by schooling quantity alone, and factors such as school quality and out-of-school learning and investments do appear to contribute in a sizeable way to cross-country gaps in economic performance. Third, human capital plays an important role in shaping the level of technology, productivity, wages and the firm size distribution, and its accumulation and allocation across different uses is an important determinant of the process of economic development. The last section of the paper elaborates on the policy implications of these general conclusions and highlights avenues for future work.

The interest for the role of human capital in promoting growth and development goes back several decades, and various previous reviews have covered similar ground to this paper. Discussions on cross-country regressions include Klenow and Rodríguez-Clare (1997a) and Pritchett (2006), while Caselli (2005) is a comprehensive review of early development accounting results. The overall message emerging from these reviews is rather stark: human capital, mostly measured by schooling quantity, explains little of cross-country gaps in economic performance. This review, based on more recent contributions, encompassing broader aspects of human capital and a wider set of methodologies, reaches a more nuanced conclusion: human capital, when measured to include the dimensions of school quality and out-of-school investments, does appear to contribute in an important way to macro-economic

development. Given the nature of the question, this conclusion is necessarily tentative, but it does appear that more recent contributions and different methodological approaches have led to a reconsideration of the macroeconomic relevance of human capital differences across countries.<sup>2</sup>

A more recent review on the micro and macro returns to human capital is Flabbi and Gatti (2018). Compared to this paper, the present review offers a more comprehensive discussion of the macro literature, including a comparison between reduced form methodologies and quantitative models, as well as an illustration of the key development accounting results using recent data. Such direct comparison between different methodologies and results on a common sample of countries allows to provide a richer characterization of which measures and dimensions of human capital are more important for economic development. On the other hand, this review does not attempt to cover the (even more extensive) literature on the micro-level returns to human capital; for that, the reader is referred to Flabbi and Gatti (2018).<sup>3</sup>

## 2. A General Framework

The starting point for most macroeconomic analyses on the effects of human capital is the postulation of an aggregate production function, which provides a mapping of the form

$$\text{Human Capital, Physical Capital, Total Factor Productivity} \longrightarrow \text{GDP}$$

between the input and output sides of the production process. In the simplest case, aggregate human capital is given by the sum of the human capital of all workers, while in richer

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<sup>2</sup>The authors of these early reviews are well aware of the fact schooling quantity represents only one of potentially many relevant dimensions of human capital. Indeed, Pritchett (2006) uses the term “schooling capital” to emphasize the distinction between educational attainment and the broader concept of “human capital”. Caselli (2005) does include measures of school quality, health and experience in his accounting exercise, finding limited effects. As discussed in section 4, more recent contributions have challenged some of these conclusions.

<sup>3</sup>Results from micro-level studies are often used as benchmarks for country-level ones and for the calibration of macroeconomic models. Some prominent examples of this practice are illustrated below.

specifications it is obtained as a more complex aggregation of different types of labor. Total factor productivity (TFP) determines how efficiently the inputs are utilized in production, and is influenced by factors such as technology and institutional quality.

This framework suggests three broad channels through which human capital plays a role in shaping cross-country differences in GDP (and GDP per worker). First, there is a direct effect implied by the fact that human capital is itself a factor of production. Countries with higher levels of human capital per worker have, mechanically, higher levels of GDP per worker (or, equivalently, growth rates of GDP per worker are positively related to growth rates of human capital). Higher levels of human capital per worker can be achieved through human capital accumulation at the individual level as well as, depending on the specific human capital aggregator, through more efficient allocations of heterogeneous workers.

Second, if human and physical capital are complementary in production, a larger availability of the former encourages the accumulation of the latter. The degree of complementarity is likely to vary across different types of physical and human capital. For example, the empirical evidence suggests that computers are more complementary with human capital than other types of equipments (Caselli and Wilson, 2004), and that capital equipment complements more college-educated workers than less skilled labor (Krusell et al., 2000).

Third, endogenous growth models emphasize that the rate of TFP growth is determined by a number of economic forces, including the availability of human capital. In particular, human capital is seen as instrumental to the development, adoption and operation of new technologies (Nelson and Phelps, 1966). A direct implication is that the level of human capital at a given point in time affects the growth rate of GDP per worker over subsequent periods.

To summarise, a simple aggregate production framework suggests several mechanisms through which human capital can affect aggregate economic performance. Human capital directly enters in the production process, encourages the accumulation of complementary inputs and facilitates the adoption of new technologies. Through these channels, human capital gaps should be reflected in cross-country differences in GDP per worker levels and

growth rates. The rest of the paper discusses alternative approaches to investigate the empirical relevance of these predictions.

### **3. Cross-Country Regressions**

In the growth literature, the earliest studies on the importance of human capital and other factors of production were based on cross-country and growth regressions. These approaches were originally motivated by the purpose of testing the predictions of the neoclassical model of growth on one hand, and endogenous growth models on the other.

The basic approach in this literature consists of running a regression of GDP per worker on proxies for physical and human capital per worker. Technology and other determinants of total factor productivity are treated as unobservable, and as such are part of the residual. The main objects of interest of this type of analysis are the coefficients on the proxies for human and physical capital as well as the R squared, which provides an estimate of the share of cross-country variation in GDP per worker “explained” by observable factors of production. A variant of this approach considers a regression of the GDP growth rate over a given time period on the initial level of human capital. The results from such regressions are typically used to test the predictions of the Nelson and Phelps (1966) and Romer (1990) models, where human capital impacts the growth rate of the economy through its role for technological change.

The vast majority of the studies employing these approaches have focused on educational attainment as a measure of human capital. More recently, however, strands of the literature focusing on alternative dimensions of human capital have developed. The next subsections consider these lines of work in turn.

#### **3.1 *Educational Attainment***

Mankiw et al. (1992) is an early implementation of the cross-country regression approach. This paper considers a version of the Solow model augmented with a process of human



capital accumulation, and estimates a specification based on the steady state expression for output per worker in that model. In the authors' preferred specification, GDP per worker is regressed on the fraction of the working age population enrolled in secondary school (a proxy for the rate of human capital accumulation), the saving rate and the rates of capital depreciation, population growth and productivity growth.

The results are supportive of an important role for human capital. The coefficient on the human capital variable is positive and highly significant. When all controls are included, the R squared of the regression is 78%, suggesting that proxies for physical and human capital account for most of the cross-country variation in GDP per worker. Moreover, in a specification based on the transitional dynamics of the Solow model, human capital is positively related to GDP growth between 1960 and 1985 (conditional on the starting level of GDP, as well as on the other determinants of the steady state income per worker).

These conclusions have been disputed in successive work, both on conceptual and econometric grounds. Conceptually, Pritchett (1996) questions the use of the enrollment rate as the regressor of interest, since this variable appears to be a poor proxy of (and even negatively correlated with) the rate of change in a country's educational capital stock. Indeed, Pritchett (1996) shows that a regression of the growth rate of GDP per worker on the growth rate of the stock of educational capital (constructed from data on the educational attainment of the labor force) yields a small and negative coefficient for the latter.

In econometric terms, the identification assumption in Mankiw et al. (1992) is that measures of physical and human capital are uncorrelated with unobservable determinants of cross-country differences in economic performance. As pointed out in Klenow and Rodríguez-Clare (1997b), countries with policies discouraging capital accumulation are also likely to have in place policies or institutions discouraging technology adoption. Moreover, differences in capital accumulation might be driven themselves by differences in country-wide productivity. These would all represent violations of the aforementioned identification assumption.

Various approaches have been proposed to overcome these identification challenges. Is-

Islam (1995) adopts a panel data approach, where time invariant “country effects” are added to the dynamic specification of Mankiw et al. (1992). To the extent that the common drivers of capital accumulation and technology adoption are indeed fixed over time, they are captured by these country effects and do not spuriously inflate the contribution of physical and human capital to output per worker. In this setting, Islam (1995) finds that proxies for human capital are not strongly related to output per worker, questioning the empirical relevance of the Solow model with human capital accumulation. While levels of school enrollment are positively related to levels of GDP per worker, the relationship is much weaker when introducing the temporal dimension.

This approach is itself subject to a number of issues. First, the least squares estimation of dynamic panel model including fixed effects is generally biased (especially for relatively short panels), as showed by Nickell (1981). Second, temporal comparisons are particularly sensitive to problems in the measurement of human capital. Given that average school attainment at the country level changes slowly over time, short-run fluctuations are likely to be mostly driven by measurement error. Indeed, Lindahl and Krueger (2001) argue that commonly used international data on educational attainment are subject to problems of incompleteness, imprecision and lack of consistency across countries. Cohen and Soto (2007) show that when using a more accurate dataset on average years of schooling across countries, increases over time in this measure of human capital are in fact positively related to GDP growth.

Other authors attempt to solve the identification problem through instrumental variables. This approach consists of finding variables (instruments) that are correlated with the variables of interest, but not with the unobservable confounders that bias the regression results to start with. By focusing on variation “induced” by these instruments, in principle one can separate the effect of the variables of interest from the one of unobservable factors.

Unfortunately, finding suitable instruments in the context of cross-country regression is a challenging task. A seminal contribution in this direction is Acemoglu et al. (2001). The paper focuses on political institutions, and proposes to identify the importance of institutional

quality for economic development by using the mortality rate among European colonizers as an instrumental variable. The logic is that colonizers created extractive institutions in colonies where they could not easily settle, whereas they attempted to recreate European institutions in environments more favourable to their inhabitancy. The main result of the paper is that the cross-country variation in institutions induced by these historical circumstances has a large effect on income per worker.

Using a similar methodology, Glaeser et al. (2004) questions Acemoglu et al. (2001)'s view on the importance of institutional quality for economic development, and argues for a central role of human capital (as measured by educational attainment). The starting point is the observation that European settlers did not just bring European institutions with themselves, but also their human capital. Indeed, Glaeser et al. (2004) show that the instrument used by Acemoglu et al. (2001) is positively correlated with current educational attainment, and argues that institutional quality is a product as opposed to a cause of the process of economic development. This view is supported by a regression specification where institutional quality and educational attainment are simultaneously instrumented for, from which it emerges that educational attainment has a stronger explanatory power for economic performance. This conclusion has been in turn questioned by Acemoglu et al. (2014), which argues that the instruments used by Glaeser et al. (2004) are not valid sources of exogenous variation.<sup>4</sup>

Recent work has shifted the focus from a national to a subnational setting. Gennaioli et al. (2013) use data at the regional level across 110 countries to examine the relative importance of human capital and other possible determinants of local economic performance. Within-country comparisons allow the authors to control for unobservable factors varying at the country-level, such as national institutions, national culture and national language. In this subnational regression specification, educational attainment emerges as the most important predictor of regional economic performance. Moreover, Gennaioli et al. (2013) use

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<sup>4</sup>The instruments used by Glaeser et al. (2004) are a dummy for French legal origin and either settler mortality or population density in 1500. As pointed out by Acemoglu et al. (2014), the rationale behind this empirical strategy is not clearly discussed, and it is even unclear whether the two instruments have distinct explanatory power when considered jointly.

firm-level data to document that entrepreneurs' and managers' human capital plays a particularly important role in explaining differences in firms' productivity. However, Acemoglu et al. (2014) argue that country fixed effects are not sufficient to eliminate omitted variable biases and that the measure of institutions used by Gennaioli et al. (2013) misses meaningful subnational variation in institutional quality.

A parallel line of work studies the effects of schooling on GDP growth. Early contributions, such as Barro (1991) and Benhabib and Spiegel (1994), find a positive and significant relationship. However, these results are subject to similar endogeneity concerns to the ones highlighted above: both the initial level of schooling and subsequent growth might be affected by third factors, and the former might also be driven by the anticipation of the latter (Bils and Klenow, 2000). Moreover, as pointed out in Pritchett (1996) and Cohen and Soto (2007), the significance of the coefficient on the level of schooling is not robust to the introduction of a control for the level of physical capital (itself likely to be endogenous).

To make progress, successive work has moved away from countries as units of observation and considered more disaggregated settings. An example of this approach is Ciccone and Papaioannou (2009), which adopts a sectoral perspective to test whether human capital favours technology adoption and growth. The authors use data for 37 manufacturing industries across 40 countries, and show that countries with higher levels of education in 1980 saw faster growth in human-capital-intensive industries (relative to other industries) in the following decades, a period characterised by the rapid introduction of skilled labor augmenting technologies. They interpret this result as evidence that high educational attainment was instrumental in the adoption of these technologies.

### 3.2 *Other Dimensions of Human Capital*

A recent strand of the cross-country regression literature proposes to go beyond measures of schooling quantity and to focus on direct proxies for knowledge and skills. The rationale for this is twofold. On one hand, if school quality varies across countries, a given level of educational attainment implies different levels of human capital depending on where it is

obtained. Moreover, by construction measures of schooling quantity do not capture skills acquired outside of the schooling system.

Hanushek and Woessmann (2012a) consider international standardized tests in mathematics and science as proxies for the stock of cognitive skills across countries. The authors document that long-run growth rates (between 1960 and 2000) across countries are positively related to the performance in these tests, and that this relationship is stronger and more robust than the corresponding association between economic growth and traditional measures of school attainment. In the baseline estimates, one standard deviation in test scores is associated with a higher average annual growth rate in GDP per worker of two percentage points.

This result is subject to similar identification concerns to those discussed above for cross-country regressions including education-based measures of human capital. Countries where students perform well in standardised tests might be inherently different in terms of culture or institutions, and these factors might explain their faster growth. Moreover, country-level economic performance itself might have an impact on school resources and students' learning, leading to concerns of reverse causality.

Hanushek and Woessmann (2012a) provide several pieces of evidence to alleviate these concerns. The authors show that the results are robust to an instrumental variable strategy based on the use of institutional features of the school system as instruments for test performance, and to a specification relating changes in performance over time to changes in growth rates. Moreover, they show that US immigrants from countries with high average test scores earn higher wages than immigrants from countries with low average test scores, but only if they were educated in their home country (as opposed to being educated in the US). They interpret this as evidence for the fact that the schooling system is the crucial factor setting apart high-scoring and low-scoring countries. While the authors acknowledge that achieving a perfectly credible identification is impossible in a cross-country setting, these different pieces of evidence all point towards an important role of cognitive skills for explaining cross-country differences in economic performance.

A natural question, though, is whether standardized tests might capture cross-country differences in noncognitive skills, such as motivation and perseverance, in addition to the cognitive skills they are primarily designed to measure. An intriguing piece of evidence on this comes from Balart et al. (2018). These authors propose to use the decline in performance during the test (controlling for the difficulty of the questions) as a proxy for students' noncognitive skills, and show that the cross-country relationship between test performance and economic growth documented in Hanushek and Woessmann (2012a) is to some extent driven by the noncognitive component. This result has potentially far-reaching implications, since the literature on skill formation suggests that the accumulation of cognitive and noncognitive skills involve different types of interventions, with a different degree of substitutability across stages of the life cycle (Cunha et al., 2010).

Another aspect of human capital that has received widespread attention in the cross-country regression literature is health. A large micro literature suggests that improvements in health and nutrition are associated with increases in labor productivity, both because of a direct effect on the workers' capabilities to perform different tasks, and because of an indirect effect on schooling and the production of other forms of human capital (see, among others, Alderman et al., 2001, 2006). A natural hypothesis is that variation in health conditions across countries might be associated with differences in economic performance.<sup>5</sup>

The estimation of cross-country regressions typically yields positive and significant coefficients on health measures (Bloom and Canning, 2000, 2003; Bloom et al., 2004). However, the fact that causality is likely to run in both directions makes empirical inference complicated in a regression setting.<sup>6</sup> Acemoglu and Johnson (2007) propose to use the change in mortality rate predicted by the effect of international health interventions on specific diseases as an instrument. They find that health improvements lead to increases in population

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<sup>5</sup>The literature on this question and its policy implications is extensive, and a complete review of it goes beyond the scope of this paper. For richer reviews on these aspects, see Alderman and Behrman (2006), Bleakley (2010) and Alderman et al. (2017).

<sup>6</sup>See Pritchett and Summers (1996) for an analysis based on instrumental variables finding positive effects of income per capita growth on health, and Bloom and Canning (2000) for a discussion on the channels underlying this bi-directional relationship.

and aggregate GDP, but not in GDP per worker.<sup>7</sup> These results highlight that the effects of health on individual-level productivity are not necessarily accompanied by corresponding effects on income per worker. A similar message emerges from Young (2005), which shows that the decrease in population associated to the HIV/AIDS epidemics in South Africa was accompanied by an increase in consumption per worker, despite the enormous human suffering caused by the disease.

### 3.3 *Taking Stock*

What do cross-country regressions teach us on the importance of human capital on a macroeconomic scale? While several results are consistent with human capital playing a role in promoting growth, the evidence is too patchy to allow definite conclusions. The identification challenges associated with cross-country regressions are formidable, and even when progress is made towards alleviating those concerns, strong doubts remain on the reliability of the results from a qualitative and, especially, a quantitative perspective.

## 4. Development Accounting

In light of the identification problems associated with cross-country regressions, researchers have turned to alternative approaches aimed at addressing the importance of capital accumulation for cross-country differences in economic performance. Development accounting is one of them.

The starting point for this approach is the measurement, for all countries at a given point in time, of the stocks of physical and human capital available in the economy. Then, instead of relying on the statistical association between these measures and GDP per worker, the development accountant uses external evidence to determine the appropriate value of the

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<sup>7</sup>Bloom et al. (2014) question the methodology and conclusions of Acemoglu and Johnson (2007). The instrument used in Acemoglu and Johnson (2007) is strongly correlated with health conditions at the start of the sample, which might have impacted economic growth in the following decades. Indeed, when Bloom et al. (2014) introduce the initial level of life expectancy as an additional control, the instrument loses any predictive power for subsequent health improvements.

parameters of the production function. With these at hand, it is possible to compute the joint contribution of physical and human capital to production, and to back out total factor productivity as a residual. This strategy mirrors the one of growth accounting, with a focus on cross-country differences at a given point in time as opposed to cross-time variation within a given country.

The typical questions asked are: how much of the cross-country variation in GDP is explained by total factor productivity as opposed to observable inputs? Do rich countries have more human and physical capital than poor countries? How would the income distribution look like if all countries had the same levels of human and physical capital?

As in the cross-country regression approach, total factor productivity is treated as an unobservable residual. However, development accounting does not involve any estimation, and as such it does not rely on implausible assumptions on the orthogonality between observable and unobservable factors of production. On the contrary, by measuring factors of production and total factor productivity independently, the development accountant can test whether capital abundance is correlated with the latter, and the relative role of physical and human capital in explaining this correlation.<sup>8</sup>

Development accounting does not come without limitations. This approach strongly relies on the postulation of a given aggregate production function and on the precise measurement of factors of production, and as such it is subject to concerns related to the unavoidable approximations associated with these tasks. Perhaps the most important limitation resides in the “accounting” nature of the exercise. Development accounting quantifies the role of human and physical capital as “proximate” causes of development, but has little to say on what is driving the cross-country variation in these factors of production to start with (the “ultimate” causes of development). Relatedly, factor accumulation and technological innovations are interdependent phenomena, and this approach is not well suited to characterise the links between the two, and therefore to ask counterfactual questions on how, for example,

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<sup>8</sup>In the cross-country regression approach, total factor productivity is estimated as the residual of the best linear relationship between the logs of GDP per worker and proxies for physical and human capital, so that by construction it is uncorrelated with the latter.



technology would respond to improvements in human capital.

In spite of these limitations, development accounting remains a useful diagnostic tool. If one finds that human capital varies greatly across countries, a natural implication is that policies aimed at stimulating human capital accumulation are a promising avenue to promote economic development. Moreover, by measuring different dimensions of human capital in different ways, one can learn which are particularly important for cross-country gaps in economic performance, therefore further restricting the range of alternative policies under consideration.

In the next subsections, this review uses recent data to replicate several alternative strategies proposed in the literature to measure human capital. The approach is cumulative: I start from measures based on educational attainment, and I gradually introduce additional dimensions to evaluate their relative importance. For each measure of human capital, I summarize the development accounting results by displaying the counterfactual distribution of GDP per worker that would prevail if all countries were assigned with the level of human capital per worker of the United States. The more this thought experiment leads to a narrowing of income gaps, the more human capital can be inferred to be an important driver of these gaps in the first place. In the body of the paper I focus on the main intuition behind each counterfactual exercise, leaving a formal illustration for the Appendix (available with this article at *The World Bank Research Observer* website).

#### 4.1 *Educational Attainment*

The first contributions in the development accounting literature focused on years of schooling as a proxy for human capital. As discussed above, this approach holds some promise as educational attainment is positively correlated in GDP per worker. However, by construction it ignores other potentially important sources of human capital accumulation, such as the quality of schooling, domestic upbringing and on-the-job learning.

Following Bils and Klenow (2000), the traditional way to convert average years of schooling into an estimate of the human capital stock makes use of microeconomic evidence

on wage returns to education. This is based on the assumption of perfectly competitive labor markets, which implies that these wage gains reflect the human capital acquired in a year of schooling. Returns to education, often referred to as Mincerian returns after the seminal work of Mincer (1974), have been widely estimated in the labor economics literature. Reviews of the international evidence (Psacharopoulos, 1994; Psacharopoulos and Patrinos, 2004; Caselli et al., 2016) suggest that on average an extra year of schooling is associated with a 10% increase in wages.<sup>9</sup>

Figure 4 illustrates the development accounting results.<sup>10</sup> For selected countries at various percentiles of the income distribution, the dark grey bars represent the counterfactual GDP per worker (relative to the United States) when educational attainment is equalized across countries. These should be benchmarked against their empirical counterparts, represented by the black bars. Given that average educational attainment is higher in the United States compared to most other countries, the counterfactual exercise leads to smaller output gaps. For the poorest countries, however, the human capital gap is substantially smaller than the gap in terms of GDP per worker, implying that the most of the latter persists even when the former is closed. The pattern is somewhat different for relatively rich countries, for which human capital accounts for the most or all the income gap with the United States.

Overall, the variation in human capital between the richest and poorest countries appears very limited. Indeed, most early contributions to the development accounting literature found a small role for educational attainment which, combined with similar results for physical capital, led to the conclusion that total factor productivity accounts for most of the cross-country dispersion in economic performance (Hall and Jones, 1999; Caselli, 2005). More recent work has challenged this conclusion by considering broader measures of human capital.

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<sup>9</sup>The use of a private return to compute human capital implicitly assumes away human capital externalities, which would create a wedge between private and social returns. The evidence for large aggregate externalities has traditionally been limited (Pritchett, 2006), though recent work by Guo et al. (2018) challenges this view.

<sup>10</sup>For this and all subsequent exercises, the measure of output per worker is GDP per worker in PPP terms for 2010, taken from version 9.0 of the Penn World Tables (Feenstra et al., 2015). The measure of average years of schooling (for the population above 25) comes from Barro and Lee (2013). All the numerical results can be found in the Online Appendix.

## 4.2 *Measure of Cognitive Skills*

This subsection considers extensions of the human capital formulation that include direct measures of cognitive skills. A recent strand of the literature incorporates the average performance in standardized tests of either school-age children (Hanushek and Woessmann, 2012b; Hanushek et al., 2017) or working-age adults (Hidalgo-Cabrillana et al., 2017) in development accounting exercises. This approach partially bypasses the problem of identifying the key *inputs* for human capital accumulation by measuring directly an *output* of that process. Differences in cognitive skills, as measured by test scores, reflect a combination of school quality (Hanushek and Woessmann, 2012a), parental influence (De Philippis and Rossi, 2016) and characteristics of the institutional environment (Woessmann, 2016).

To measure cognitive skills, this review relies primarily on the dataset constructed by Hanushek and Woessmann (2012a), who combine results from various standardized tests and express them on a common metric. This database is integrated with additional test results for Latin American countries that the same authors provide in Hanushek and Woessmann (2012b). While the tests used for the construction of the dataset were administered across different decades and to school-age children only, cross-country gaps in performance are quite persistent over time, suggesting that these measures of cognitive skills are to a large extent relevant for the current labor force as well.

The computation of human capital stocks is once again based on microeconomic evidence. By the same logic illustrated above, the mapping between years of schooling and test scores can be captured by estimates of the associated wage returns. It is important to focus on estimates that consider both variables jointly, since cognitive skills and educational attainment are likely to be positively correlated, and omitting one will inflate the contribution of the other. Hanushek et al. (2017), based on a comprehensive review of the evidence, concludes that a year of schooling and an individual-level standard deviation in test scores are associated respectively with a 8% and 17% return in terms of wages.

The light grey bars in Figure 4 show the development accounting results. Compared

to the measure of human capital based on educational attainment only, closing the gap in terms cognitive skills reduces slightly the income gap between the United States and the poorest countries, and increases the corresponding gap between the United States and the other high-income countries. This reflects the fact that the average test performance of students in the United States, while substantially superior to the one of students in many developing countries, puts them only at the 65<sup>th</sup> percentile of the international distribution. Indeed, measures of cognitive skills are more effective in explaining income gaps between East Asian countries on one hand, the top performers in standardized tests, and low- to middle-income countries on the other (Hanushek and Woessmann, 2012b).

#### 4.3 *Health and Experience*

Other strands of the literature have contributed to the development accounting debate by attempting to measure directly different aspects of human capital. This subsection focuses on health and experience.

Weil (2007) proposes to use the survival rate to the age of 65 as a proxy for the health status of the population. This is an attractive measure, since it implicitly reflects the incidence of all sources of mortality, and at the same time is available for a large sample of countries. However, one cannot rely directly on microeconomic evidence to map such measure into an estimate of human capital, since the survival rate is an aggregate statistics and by definition does not vary within countries. To bypass this problem, Weil (2007) exploits the fact that, over time, the survival rate is strongly correlated with average height, and that wage returns to height can be estimated using micro-level variation. His estimates imply that an increase in the survival rate of 10 percentage points corresponds to an increase in human capital of about 7%.<sup>11</sup>

The white bars in Figure 4 show the corresponding development accounting results. For relatively poor countries, closing the health gap (in addition to closing the educational attainment gap) with respect to the United States moderately reduces GDP gaps, while the

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<sup>11</sup>The survival rate to 65 by gender is taken from the World Development Indicators (World Bank, 2019), and the average rate is computed using the gender composition of the population. All data refer to 2010.

opposite is true for relatively rich countries.

Another potentially important dimension of human capital is labor market experience. The process of learning does not stop at the end of one's schooling career, and it is reasonable to think that rich and poor countries might offer differential opportunities for human capital accumulation even at a later age. Traditionally, the development accounting literature dismissed this dimension of human capital on the ground that the *quantity* of potential experience is not positively correlated with GDP per worker. While life expectancy is higher in rich countries, longer schooling careers imply that individuals in those countries enter later in the labor market. Klenow and Rodríguez-Clare (1997b) and Caselli (2005) document that on balance this leads, if anything, to a higher average experience in poorer countries. Since the micro evidence suggests that experience is positively correlated with earnings, adding this component by assuming a common return across countries unavoidably leads to a smaller contribution of human capital to income differences.

Lagakos et al. (2018a) argue however that returns to experience do vary across countries. The authors estimate the experience-wage profiles of US immigrants, and show that those coming from richer countries have higher returns to both US and foreign experience. In a separate paper, they document that a similar gap exists when looking at non-migrants across a smaller set of rich and poor countries (Lagakos et al., 2018b). They interpret these results as evidence for the fact that workers born in rich countries accumulate more human capital over their life-cycle, possibly because of differences in the quantity and quality of their education.

Figure 5 shows the results of a development accounting exercise based on Lagakos et al. (2018a)'s country-specific estimates for the returns to experience. The sample here does not include the United States, since the estimates are based on returns to foreign experience of US immigrants, and New Zealand. France is set as the benchmark country for the counterfactual exercise, and Greece is included to represent countries around the 75<sup>th</sup> percentile of the income distribution. Equalizing returns to experience substantially reduces income gaps. For example, consider France and Ghana, the first being about 14 times richer than

the second in the data: closing the educational attainment gap would reduce the GDP difference to a factor of 10, while closing the gap in terms of returns to experience would further reduce it to a factor of 4. Overall, the accumulation of human capital during workers' career appears to be an important source of cross-country differences in economic performance.

#### 4.4 *Development Accounting with Migration Data*

This subsection discusses further recent work using migration data to investigate cross-country differences in human capital. The premise of this approach is that migrants “bring with themselves” the human capital accumulated in their country of origin, but then face a common technological and institutional environment in the new host country. Therefore, comparing earnings across migrants' nationalities is informative on the cross-country variation in human capital, since it allows to keep constant the impact of other factors of production. Of course, these exercises need to take into account that migrants are not randomly selected from the labor force of their country of origin, and that their labor market outcomes in the new host country do not depend solely on their human capital.

The first implementation of this idea is Hendricks (2002). He documents that gaps in terms of average wages between US natives and immigrants from poor countries to the US are relatively small, and concludes from this that the cross-country variation in human capital must be limited. However, subsequent work points out that Hendricks (2002)'s findings are consistent with some degree of positive selection of immigrants and larger cross-country differences in human capital (Seshadri and Manuelli, 2014).

The subsection illustrates in greater detail two recent extensions of this approach. Schoellman (2012) focuses on returns to schooling for foreign-educated immigrants. He shows that, within the United States, the wage gain associated with an extra year of schooling is higher for immigrants educated in rich countries compared to those educated in poor countries. He infers from this that educational quality is higher in rich countries. This conclusion does not rely on the migrants being representative of non-migrants from the same country, but on the weaker assumption that there is no differential selection either across levels of educa-

tional attainment or on returns to schooling. The author provides several pieces of evidence suggesting that these are not major concerns.

Schoellman (2012) proposes a model of endogenous human capital accumulation to construct a mapping between educational quality, as proxied by the estimated returns to education for immigrants, and human capital per worker. In the model, both years of schooling and the Mincerian return are endogenous objects. In equilibrium, higher educational quality increases the former, because of the complementarity between schooling quantity and quality in the human capital production function, but not the latter. The key implication for development accounting is that a given gap in years of schooling reflects a larger gap in human capital than what implied by the wage return alone.

Figure 6 shows the corresponding development accounting results. When the human capital stock is constructed as in Schoellman (2012), the counterfactual income distribution (dark grey bars) is substantially more compressed than in the data (black bars). The income gap between the United States and Ghana goes from a factor of 17 in the data to a factor of 5 in the counterfactual; the corresponding gap between the United States and the Philippines goes from a factor of 7 to a factor of 3.

In a subsequent study, Hendricks and Schoellman (2018) use data on wage gains at migration to provide yet another perspective on cross-country differences in human capital. Their approach identifies human capital as a residual: wage gains at migration are informative on combined effect of technology and physical capital, and the cross-country dispersion that remains after accounting for these factors can be attributed to human capital. Importantly, comparing pre- and post-migration wages of the same individual, as opposed to comparing wages of migrants and non-migrants, allows to sidestep the issue of migrants' selection. Moreover, this exercise does not require to impose any structure on the sources of human capital differences across countries: since human capital is measured as a residual, its variation might reflect a combination of the quantity and quality of education, as well as of all other country-specific inputs relevant for human capital formation.

Hendricks and Schoellman (2018) display the average wage gains across five groups of

countries, corresponding to the five quintiles of the GDP per worker distribution in 2005. To implement a version of their development accounting exercise, the sample countries considered so far are assigned with the average wage gain of the relevant group (implicitly assuming no change in this quantity between 2005 and 2010), so that the counterfactual level of output with human capital at the US level can be computed. The results are displayed in Figure 6 (light grey bars). This measure of human capital accounts for a substantial part of cross-country gaps in economic performance, and particularly so for relatively poor countries. Since wage gains upon migration are small relative to GDP gaps, human capital per worker is inferred to vary substantially across countries.

These results illustrate the usefulness of studying migrants' outcomes to understand cross-country gaps in human capital. This line of work is currently very active, and branching out in multiple directions. This is not surprising: rich data on migrants' labor market outcomes are increasingly available across several host countries, and the micro-level heterogeneity in various aspects of the migration and assimilation processes allows researchers to isolate different dimensions of cross-country gaps in human capital. This subsection concludes by illustrating two recent contributions that apply this strategy to quantify the importance of two further determinants of human capital: early-childhood investments and cultural traits.

Schoellman (2016) exploits the variation in the age of arrival to the US of Indochinese refugees to estimate the importance of the country-specific environment for early childhood human capital investments. Refugees arrived later to the US spent more of their childhood in a relatively poor countries and less in the United States; if the country environment is an important component of early childhood human capital accumulation, we would expect these refugees to earn less when adults compared to those arrived earlier.<sup>12</sup> The results in Schoellman (2016) do not support this hypothesis: refugees' adult labor market outcomes are independent of their age of arrival. In light of the micro literature showing that early-

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<sup>12</sup>The focus on refugees is meant to alleviate concerns on migrants' selection: the unpredictable nature of the circumstances Indochinese families were fleeing from, as well as the long and variable transit times make it unlikely that differences in the children's arrival age were driven by unobservable pre-migration characteristics.



childhood investments are important determinants of adult outcomes (and that subsequent remediation is difficult), the author speculates that parents rather than country environments might be the primary source of cross-country gaps in early childhood human capital.

Ek (2018) uses rich Swedish administrative data to estimate firm-level production functions, where workers' productivity is allowed to depend, among other factors, on their country of origin. One advantage of this approach, compared to others reviewed in this subsection, is that it does not rely on the assumptions that wages accurately reflect marginal products, and is robust to various possible forms of wage discrimination against migrants. The exercise uncovers large cross-country differences in human capital, consistently with Hendricks and Schoellman (2018). Moreover, Ek (2018) relates in a cross-country regression setting his estimate of human capital with various country-level characteristics, and finds that cultural traits, and in particular the degree of individuals' autonomy, are the strongest predictors. This finding suggests the intriguing possibility that cross-country gaps in workers' productivity are partially driven by deep-rooted cultural factors.<sup>13</sup>

#### 4.5 *Imperfect Substitution*

All the approaches reviewed so far treat workers with different levels of human capital as perfect substitutes. This is an extreme assumption, as it implies that more and less educated workers supply the same type of inputs in the production process, the difference between the two groups being solely a matter of embedded productivity. Empirical studies (mostly with US data) provide evidence against this assumption, since the relative wage of skilled and unskilled workers appears to react to changes in their relative supply, as predicted by frameworks with imperfect substitutability between the two (Katz and Murphy, 1992; Ciccone and Peri, 2005).

A recent line of work investigates the implications of relaxing this assumption for development accounting. Caselli and Ciccone (2013) show that allowing for imperfect substi-

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<sup>13</sup>This hypothesis has a long history in the social sciences, going back to Weber (1930). The results in Ek (2018) are consistent with a broader literature on the importance of culture for economic outcomes; see Guiso et al. (2006) for a review.

tutability between skill types necessarily reduces the contribution of human capital, when measured by educational attainment. Intuitively, under imperfect substitutability increasing the share of skilled (highly educated) workers has two effects: an increase of the share of the most productive workers (which increases output), and a decrease in the relative marginal productivity of skilled and unskilled workers (which decreases output). With perfect substitutability the second effect is not present, and therefore the results obtained under this assumption can be treated as an upper bound for the contribution of schooling quantity in development accounting.

However, imperfect substitutability has implications for the measurement of other dimensions of human capital (beyond schooling quantity). As an illustration, consider the simple case where the aggregate human capital stock is a combination of two types of workers, skilled and unskilled, which are imperfect substitutes in production. This framework predicts that the relative price of the labor services supplied by skilled and unskilled workers should be decreasing in their relative supply. However, a key empirical observation is that the relative wage of skilled and unskilled workers (i.e., the skill premium) does not vary much across countries, even though rich countries are much more abundant in skilled labor (Caselli and Coleman, 2006; Jones, 2014; Rossi, 2017). This suggests that skilled workers are relatively more “efficient” in rich countries, therefore preventing the skill premium to fall in those countries as much as one would expect based on their high relative supply.<sup>14</sup>

The implications for development accounting depend on the interpretation of this cross-country variation in the relative efficiency of skilled labor. Jones (2014) attributes it to differences in unmeasured human capital (for given levels of educational attainment), and shows that it can dramatically boost the contribution of human capital in accounting for cross-country income gaps. In contrast, Caselli and Coleman (2006) interpret it as reflecting skill-biased technological differences across countries (i.e. firms in rich countries adopting more skilled labor augmenting technologies compared to poor countries), and Caselli and

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<sup>14</sup>Malmberg (2018) confirms the result that skilled workers are relatively more efficient in rich countries through a different empirical strategy, based on the analysis of trade patterns for skilled- and unskilled-intensive manufacturing goods.

Ciccone (2019) show that under this interpretation the role of human capital for development accounting is much more limited.

Figure 7 illustrates these different results.<sup>15</sup> The dark grey bars represent the counterfactual levels of output per worker when human capital is constructed as in Jones (2014). Equalizing human capital has dramatic effects on the GDP distribution, with all countries above the 45<sup>th</sup> percentile reaching or overtaking the United States, and poorer countries considerably reducing the gap. This result is driven by the fact that the relative efficiency of skilled labor is dramatically higher in the United States, and under Jones (2014)’s interpretation, this implies enormous cross-country gaps in human capital. The light grey bars show the results of the alternative exercise proposed in Caselli and Ciccone (2019). Here, the counterfactual only closes the gap in terms of the quantity of skilled and unskilled labor, while the relative efficiency of the two is kept as in the data. The results suggest that equalizing educational attainment would have a small (and, for several countries, negative) impact on relative GDP per worker.

A key take-away from Figure 7 is that understanding the nature of the cross-country variation in the relative efficiency of skilled labor is crucial to evaluate whether imperfect substitutability amplifies the role of human capital in development accounting. Rossi (2017) addresses this issue through a strategy based on the comparison of skill premia across migrants’ nationalities, and finds that the variation in relative efficiency is driven to a large extent by cross-country differences in the skill bias of technology, as argued in Caselli and Coleman (2006). This suggests that the measurement approach in Jones (2014) might overstate the extent to which human capital varies across countries.

#### 4.6 *Taking Stock*

Development accounting provides a rich picture of the cross-country variation in human capital and its importance for gaps in economic performance. From the approaches reviewed

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<sup>15</sup>The shares of skilled and unskilled workers are constructed from Barro and Lee (2013)’s data on educational attainment of the population above 25. All workers with at least some tertiary education are classified as skilled.

here, a few messages emerge. First, while educational attainment is higher in rich countries, by itself this contributes relatively little to cross-country differences in income. Second, human capital gaps are more pronounced when dimensions such as educational quality, health and experience are taken into account. Third, approaches that identify human capital as a residual find even larger cross-country differences, suggesting that some important dimensions of its variation are not captured by the available observable proxies.

It is useful to remind the reader at this point of the accounting nature of these results. The fact that human capital can account for a large share of cross-country differences in GDP is an useful starting point, but is not directly informative on how these human capital gaps could be closed in practice, or even what the equilibrium effect on output of closing these gaps would be (given that development accounting does not capture the endogenous adjustment of technology or of other aspects of the production process). For these counterfactual questions, one needs a structural model.

## **5. Quantitative Theory**

An alternative approach to the ones described above is to use quantitative models to understand how much and why human capital is associated with economic development. This allows to bypass some of the measurement issues associated with development accounting and cross-country regressions. Moreover, models are more suitable to ask counterfactual questions (such as, how much would income increase if a given human capital policy was implemented?), given that they can incorporate general equilibrium effects and the link between policy interventions and the endogenous responses of economic actors.

This section reviews the insights from two broad types of models. First, models where human capital is accumulated endogenously, as a response to various economic fundamentals. Second, models on the allocation of the human capital of heterogeneous individuals and its consequences in terms of the organization of production.

### 5.1 *Models of Endogenous Human Capital Accumulation*

The models reviewed in this subsection treat human capital as the endogenous outcome of investment decisions. They can be seen as providing a mapping

$$\text{Total Factor Productivity, Demographics, Institutions ...} \longrightarrow \text{Human Capital}$$

where the rate of investment in human capital depends on a number of exogenous country-specific factors. Different contributions in the literature vary on how broad the notion of human capital they adopt is (i.e. years of schooling vs other dimensions) as well as on which determinants of human capital investment they emphasize.

This structure can be used to ask two types of (related) questions. First, what explains the dispersion in observable components of human capital, either across countries and over time? Second, for a given observed dispersion in total factor productivity and other possible determinants of human capital investment, how much can we infer human capital as a whole to be varying across countries? The latter is closely related to development accounting, though here the direct measurement of human capital is replaced by the computation of the equilibrium outcome of a human capital accumulation model.

A seminal contribution in this literature is Bils and Klenow (2000). This paper focuses on educational attainment as the only source of human capital accumulation, and proposes a model where average years of schooling directly responds to future economic growth. This is because the benefit of more schooling is proportional to future productivity (through its effect on future wages), while the cost is proportional to current productivity (through its effect on the opportunity cost of not working). This result, combined with a relatively limited role of schooling in a growth accounting exercise, leads the authors to conclude the correlation between educational attainment and subsequent economic growth is more the result of reverse causality and omitted factors than a causal effect of the former on the latter.

The approach in Bils and Klenow (2000) illustrates how quantitative theory can complement reduced form empirical methods to understand the nature of the cross-country rela-

tionship between average schooling and growth. As discussed in section 3, a regression of any of these two variables on the other would be subject to daunting endogeneity concerns, and it is difficult in such a setting to come up with suitable natural experiments or instrumental variables. By using a theoretical model calibrated to be consistent with wage returns to schooling across countries, Bils and Klenow (2000) can quantify the relative importance of the two directions of causality and conclude that the one that goes from growth to schooling is the most important one. Of course, such a conclusion is contingent on the reliability of various modeling choices, some which are inherently difficult to motivate or test empirically (such as the functional form of the human capital production function).

Several subsequent contributions have built on the approach of Bils and Klenow (2000), extending it in two main directions. First, several authors have considered different determinants of educational choices. Second, the focus has gradually shifted from years to schooling to richer dimensions of human capital accumulation.<sup>16</sup>

As pointed out by Cordoba and Ripoll (2013), the mechanism in Bils and Klenow (2000) can account for a small part of the cross-country dispersion in years of schooling. To improve on this, Cordoba and Ripoll (2013) consider a model of educational investment with credit frictions, and find that cross-country differences in fertility, mortality and access to public education are the most important drivers of the international dispersion in years of schooling. Moreover, by modeling private and public expenditures on educational services, their approach delivers endogenous cross-country differences in the “quality” of schooling, and gaps in human capital per worker larger than those that can be inferred from years of schooling alone.

Other papers share Bils and Klenow (2000)’s focus on country-wide productivity as the key driver of interest, but study its effects on a wider set of human capital investments, not limited to years of schooling. Erosa et al. (2010) consider a model where human cap-

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<sup>16</sup>A recent paper that builds on Bils and Klenow (2000) but does not fit this description is Restuccia and Vandenbroucke (2014). As Bils and Klenow (2000), Restuccia and Vandenbroucke (2014) examine the effect of productivity (as well as life expectancy) on educational attainment; however, they augment the educational choice model with an endogenous labour supply margin and non-homothetic preferences over consumption. The key result is that such model can quantitatively replicate both the cross-sectional and the time-series differences in educational attainment across rich and poor countries.

ital depends on two inputs: schooling time and goods (such as food, health investments, extracurricular activities, and so on). They show that a higher TFP increases the benefit and the time cost of schooling, but not the cost associated with the expenditures on goods. Since their calibration implies a large role for the latter, the model predicts that individuals in countries with higher levels of TFP endogenously accumulate more human capital, therefore amplifying the effect of TFP on output. Seshadri and Manuelli (2014) find an even larger amplification of TFP differences due to human capital accumulation. Compared to Erosa et al. (2010) and Cordoba and Ripoll (2013), this paper adds post-schooling human capital accumulation, in the form of on-the-job training, and an explicit role for early childhood investments. The authors find that relatively small differences in TFP are associated with large gaps in human capital per worker, and that these gaps are mostly driven by schooling quality (i.e. the amount of human capital accumulated in a given year of schooling) and pre- and post-school investments as opposed to schooling quantity.

A related question is how distortions faced by firms, emphasized in the misallocation literature as primary drivers of cross-country differences in productivity (Hsieh and Klenow, 2009), affect human capital accumulation. Guner et al. (2018) provide an analysis of this issue. Their work is motivated by a novel empirical fact: in rich countries, the life-cycle earnings growth of managers is steeper compared to poor countries, over and above the corresponding gap for other high-skilled occupations. To explain this, they develop a span-of-control model, where managers endogenously invest in their skills in order to grow the size of their firm. The key result is that size-dependent distortions, i.e. regulations, taxes and frictions that are more severe for large firms, depress the investment in managerial skills and explain a substantial fraction of cross-country gaps in managerial quality and output.

These papers illustrate a further key contribution of models of endogenous human capital accumulation. By explicitly modeling the mapping between human capital and various country-level factors, and based on an empirically motivated calibration of the exogenous parameters of the model, this methodology delivers a quantification of cross-country gaps in human capital. As discussed in the previous sections of this review, measuring human capital

is a complicated task, and observable proxies such as years of schooling, test scores or health measures are likely to miss an important part of the picture. These model-based measures represent useful complements to development accounting for quantifying the cross-country variation in that part of human capital not captured by these proxies. Indeed, the insights from recent quantitative models resound well with those of recent development accounting contributions: human capital gaps are substantially larger than gaps in educational attainment.

Moreover, differently from development accounting, quantitative models can be easily used for rich counterfactual exercises. This is crucial, as it shifts the focus from the interesting but descriptive question “is human capital more abundant in rich countries?” to the more pragmatic “which policies or fundamental factors should change in poor countries, in order for them to close the human capital gap with rich countries?”. The results illustrated in this subsection have some interesting implications on this point. While some of the contributions above suggest an important role for the extension of public education and the alleviation of credit constraints, a common theme is that human capital investments respond strongly to country-wide productivity growth. As a consequence, policies addressing the low productivity problem of poor countries might be as or more effective than traditional educational policies in encouraging the accumulation of human capital.

## 5.2 *Models of Human Capital Allocation*

So far, the discussion in this review has mostly focused on the determinants and the variation of average human capital per worker. Recently, several papers have emphasized instead the heterogeneity of skills within a given economy, and the various ways this affects and is affected by the process of economic development. This subsection briefly reviews contributions on the allocation of different types of human capital in the production process.

A key insight emerging from this literature is that frictions preventing workers from pursuing their comparative advantage are harmful for aggregate economic performance. Hsieh et al. (2013) study the consequences of the discrimination against women and blacks in



the United States. They consider a model of human capital accumulation and occupational choice, where individuals have heterogeneous talents for different occupations. Blacks and women face barriers that limit both their educational and occupational choices. The entity of these barriers can be inferred from the equilibrium conditions of the model, allowing the authors to evaluate to what extent these frictions have been changing over time. The key result is that the allocation of talent improved substantially between 1960 and 2008, contributing to aggregate wage and productivity growth.

While these results are relative to the US, the misallocation of human talent likely represents an even larger problem in developing countries. Lagakos and Waugh (2013) show that subsistence requirement lead workers relatively unproductive in agriculture to work in that sector, while Jaimovich (2011) argues that the increase in sectoral variety associated with development improves the allocation of entrepreneurial talent. Other factors that have been linked to human capital misallocation are financial frictions (Buera et al., 2011) and intergenerational occupational persistence (Sinha, 2016). Overall, this line of work suggests that improving the allocation of existing talent might be as important as encouraging the accumulation of new human capital.

Another strand of this recent literature has focused on understanding how the endogenous allocation of production roles across individuals with different skills is related to the process of economic development. Many of these papers build on two seminal contributions: Lucas (1978) and Kremer (1993). Lucas (1978) develops a model where the most talented individuals become managers and leverage their human capital by increasing the size of their firms. Kremer (1993) illustrates how a production function where the quantity of workers on a given task cannot be substituted for the quality of their skills generates patterns of assortative matching in production teams, as well as an amplified effect of skills on wages and productivity. More recent contributions have extended these frameworks along several dimensions, as well as calibrated the models to evaluate the quantitative importance of the proposed mechanisms. This subsection concludes by illustrating two recent examples.

Roys and Seshadri (2014) introduce two variations to the framework in Lucas (1978):

endogenous human capital accumulation decisions and imperfect substitutability between the quantity and quality of workers. By calibrating the country-specific (exogenous) values of total factor productivity to match the cross-country dispersion in GDP, the model is able to account for many cross-country patterns on the organization of production, such as lower firm and wage growth and higher dispersion in firm and labor productivity in poor countries.

Porzio (2017) studies the interaction between the allocation of talent across production teams and technology adoption choices. His model predicts that in poorer countries, where firms have the opportunity to import technologies much more advanced than the locally prevailing vintage, the equilibrium allocation features more concentration of talent and more productivity dispersion across firms. This prediction is supported by the fact that in developing countries workers with different skills, as proxied by educational attainment, are relatively more segregated across different sectors. A calibration of the model suggests that the proposed mechanism is able to account for a sizeable part of the larger productivity dispersion across sectors in poor countries.

This line of research is only in its early stages, and still far from definite conclusions. However, these contribution do suggests that the accumulation and allocation of human capital is a key factor in shaping many features of economic development. Moreover, the papers reviewed here support and enrich the insight that country-wide productivity is a key driver of skill investments. As a consequence, any policy that is successful in promoting productivity growth in developing countries will have a quantitatively important impact on the accumulation and allocation of human capital.

### 5.3 *Taking Stock*

Compared to development accounting and reduced form empirical methods, quantitative models can enrich our understanding of the role of human capital for economic development along several dimensions. First, the specification of a structural model allows to bypass the endogeneity concerns associated with reduced form empirical analysis. Second, the calibration and simulation of a model provides an alternative way to quantify the variation

in otherwise difficult to measure components of human capital. Third, and perhaps most importantly, a quantitative model provides a laboratory where counterfactual exercises (such as changes in policies or technological parameters) can be performed. On the other hand, the limitations of this approach are obvious. The conclusions from these exercises depend on the model's assumptions, as well as on the accuracy of the chosen calibration.

With these caveats in mind, the following key messages emerge from this literature. Across countries, the accumulation of human capital and its allocation across production teams respond to economic and institutional characteristics. The key margin for human capital accumulation is not schooling quantity, but a combination of choices that determine the productivity of a given time spent in school and out-of-school human capital investments. Policies that promote productivity growth are likely to have a large impact on both the average level of human capital and its allocation across firms and sectors.

## **6. Conclusions**

Economists have studied the macroeconomic importance of human capital through a variety of methodologies. This review discusses their advantages and limitations, and illustrates how these approaches allow to quantify the importance of different dimensions of human capital and to highlight different aspects of its two-way relationship with economic development.

An overarching consideration of the findings from cross-country regressions, development accounting and quantitative models leads to some general lessons. While average educational attainment in rich countries is much higher compared to poor countries, the gap in the quantity of schooling is not a primary driver of cross-country gaps in economic performance. However, cross-country gaps in human capital are much larger than cross-country gaps in educational attainment. This is due to differences in school quality, health, returns to experience and, to a large extent, other unobserved factors picked up by methodologies that infer human capital gaps indirectly (such as development accounting on migrants' data, or calibrated quantitative models). These broader measures of human capital do play a large

role in explaining cross-country gaps in economic performance. Moreover, international gaps in human capital investments are to a large extent driven by underlying differences in productivity and institutional factors, and the accumulation and allocation of skills play an important role in shaping technology adoption, wages and the firm size distribution along the process of development.

These findings have important implications for policy. First, for a country considering educational policies with the objective of promoting economic growth (an important qualifier, as I argue below), formal educational attainment is not necessarily the most effective margin. The results from all the approaches reviewed here suggest that improving school quality, health conditions and, admittedly a less concrete point, encouraging out-of-school human capital investments will lead to higher returns. However, a few caveats are in order. Economic growth should probably not be the only (or even a primary) consideration for policies aimed at increasing educational attainment; the enrollment in formal education has several other benefits, both from an individual and a collective perspective.<sup>17</sup> The results from this review should not therefore be read as a call for a reduction of governments' efforts in promoting formal education, but as a warning on the (limited) macroeconomic implications of such policies.

Second, the findings from the calibration of quantitative models suggest other avenues through which policy might encourage human capital investments. The key insight is that human capital, in terms of both schooling quantity and other dimensions, responds strongly to changes in factors that determine the extent to which it can be accumulated cheaply and used effectively, such as the level of a country's productivity. An implication of this is that policies promoting productivity growth, such as the removal of distortions faced by firms, improvements in the functioning of the credit market or incentives for technology adoption, would lead as a side-effect to higher investments in human capital, possibly amplifying their positive impacts on the economy.

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<sup>17</sup> Among others, Lochner and Moretti (2004) document a negative effect of education on the probability of engaging in criminal activities, Milligan et al. (2004) a positive effect on civic participation, Currie and Moretti (2003) a positive effect on child health outcomes and Easterbrook et al. (2015) a positive effect on wellbeing indicators.

A key theme of this review is that human capital differs across countries along dimensions not perfectly captured by the available data on years of schooling, health and test scores. The formulation of effective policies requires therefore a more detailed understanding of what other factors are important drivers of this dispersion in human capital (or, alternatively, an understanding of what the approaches inferring human capital indirectly are getting wrong). This represents perhaps the most promising avenue for future research on human capital and macro-economic development. There is no lack of potential candidates: early-childhood investments, non-cognitive skills, within-family interactions, institutional features of educational systems and firms' organisational structure are all known to be important at the micro level, and are likely to be important at the macro level as well. Some of the recent papers reviewed here do take important steps in quantifying some of these factors. Further progress is likely to come from a combination of more detailed data for cross-country comparisons along these dimensions, macro models incorporating these factors and creative empirical strategies to estimate their quantitative importance.

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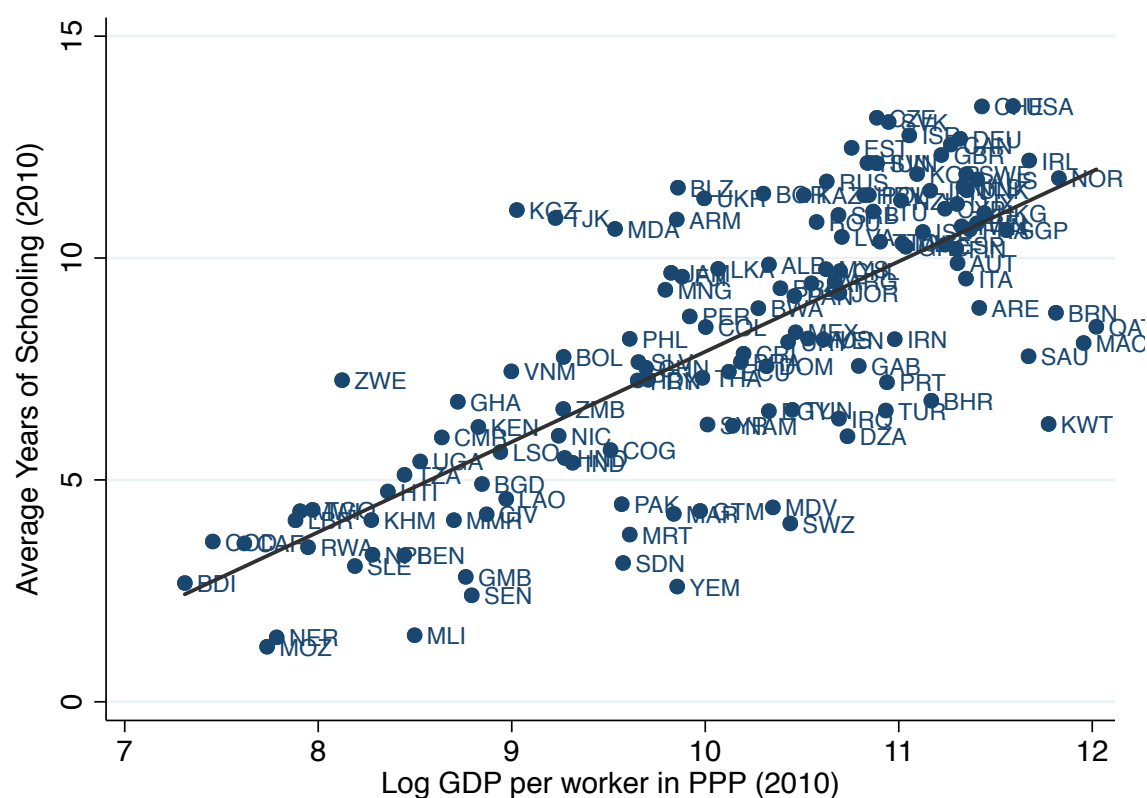
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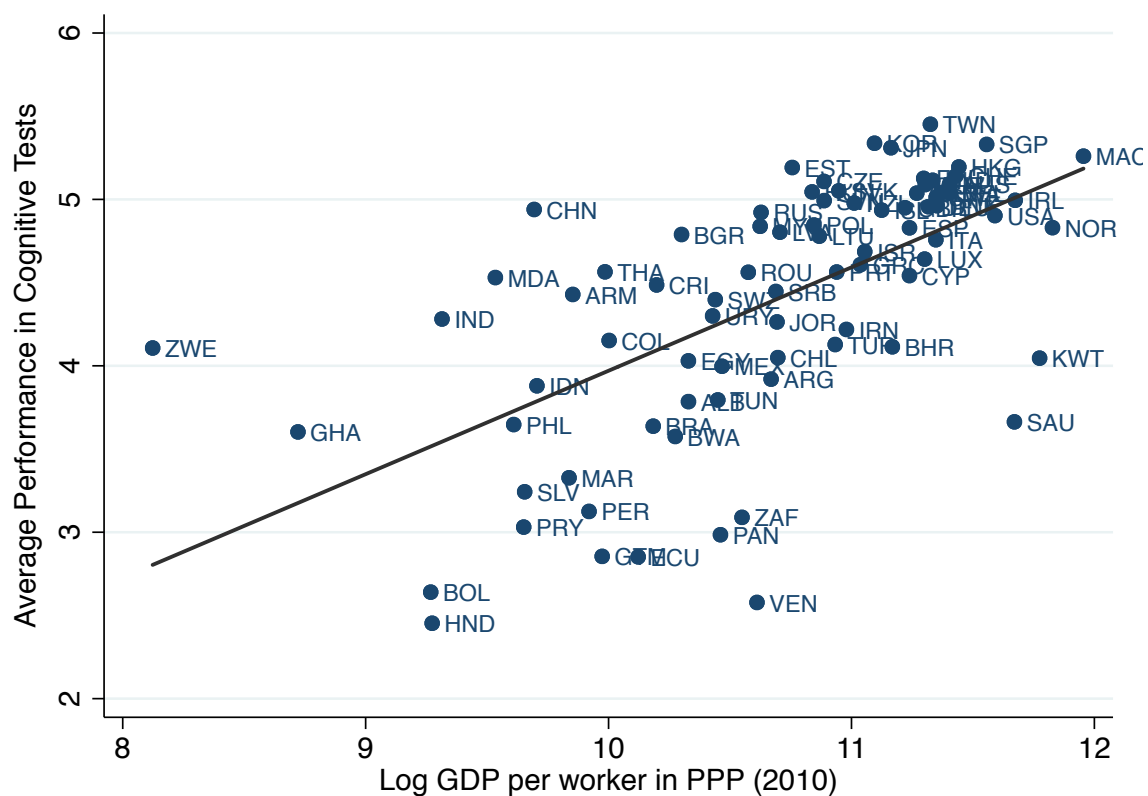
# Figures

Figure 1: Educational Attainment and Economic Development



*Notes:* The figure plots average years of schooling in the population above 25 against log GDP per worker (in PPP terms) in 2010. Average years of schooling is taken from Barro and Lee (2013), while GDP per worker is taken from version 9.0 of the Penn World Tables (Feenstra et al., 2015).

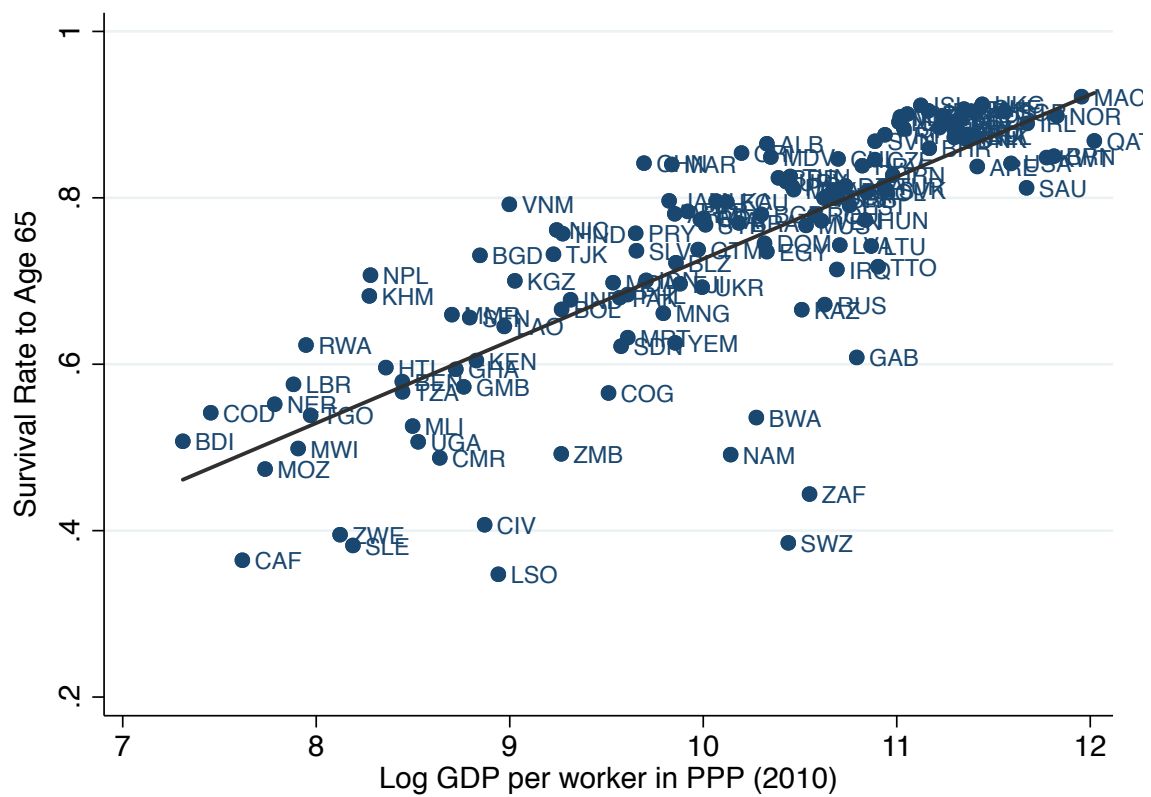
Figure 2: Performance in Cognitive Tests and Economic Development



*Notes:* The figure plots the average performance in a sample of standardized cognitive tests from Hanushek and Woessmann (2012a) and Hanushek and Woessmann (2012b) against log GDP per worker (in PPP terms) in 2010, taken from version 9.0 of the Penn World Tables (Feenstra et al., 2015). Test scores are normalized so that the individual-level average and standard deviation across students in OECD countries are 5 and 1 respectively.

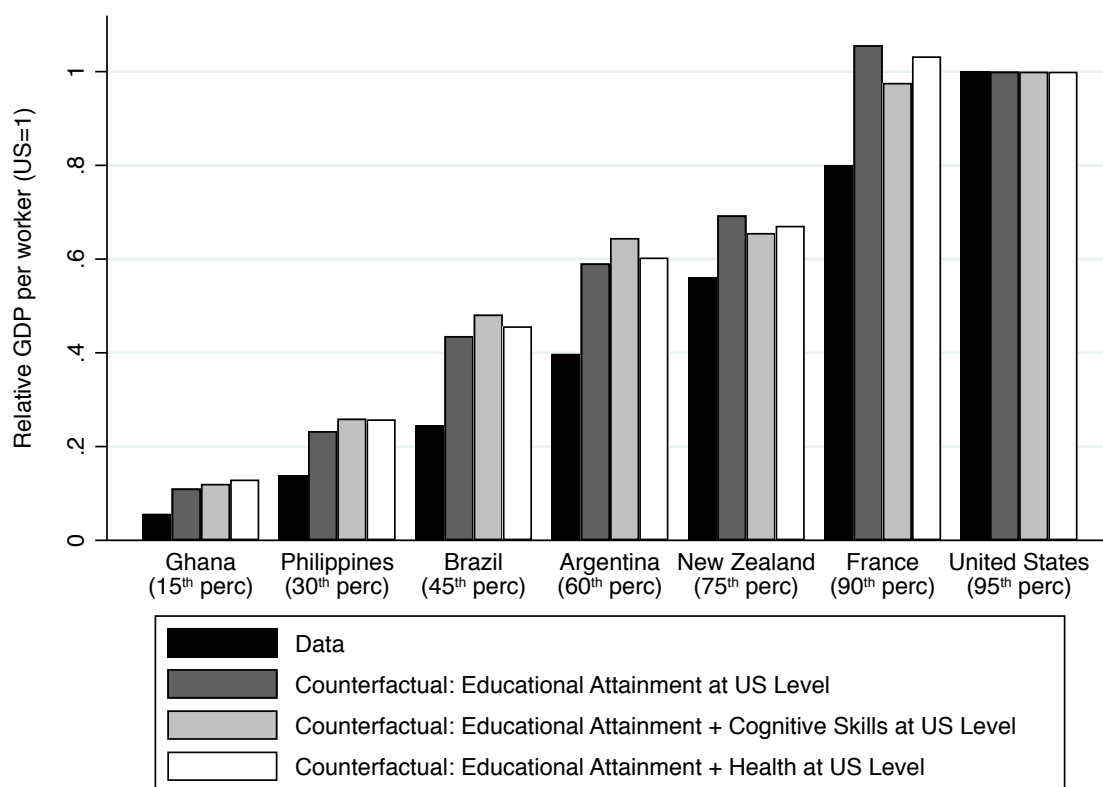


Figure 3: Health and Economic Development



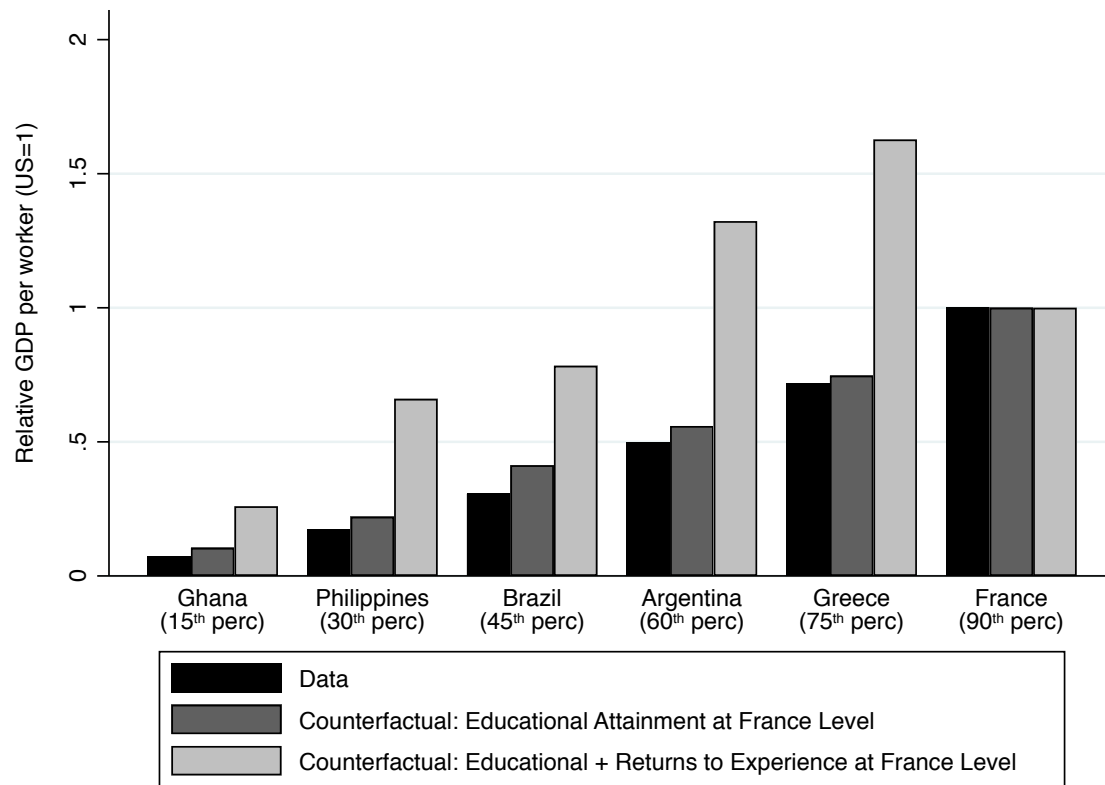
*Notes:* The figure plots the survival rate to age 65 against log GDP per worker (in PPP terms) in 2010. The survival rate is computed from the World Development Indicators (World Bank, 2019), while GDP per worker is taken from version 9.0 of the Penn World Tables (Feenstra et al., 2015).

Figure 4: Development Accounting: Educational Attainment, Cognitive Skills and Health



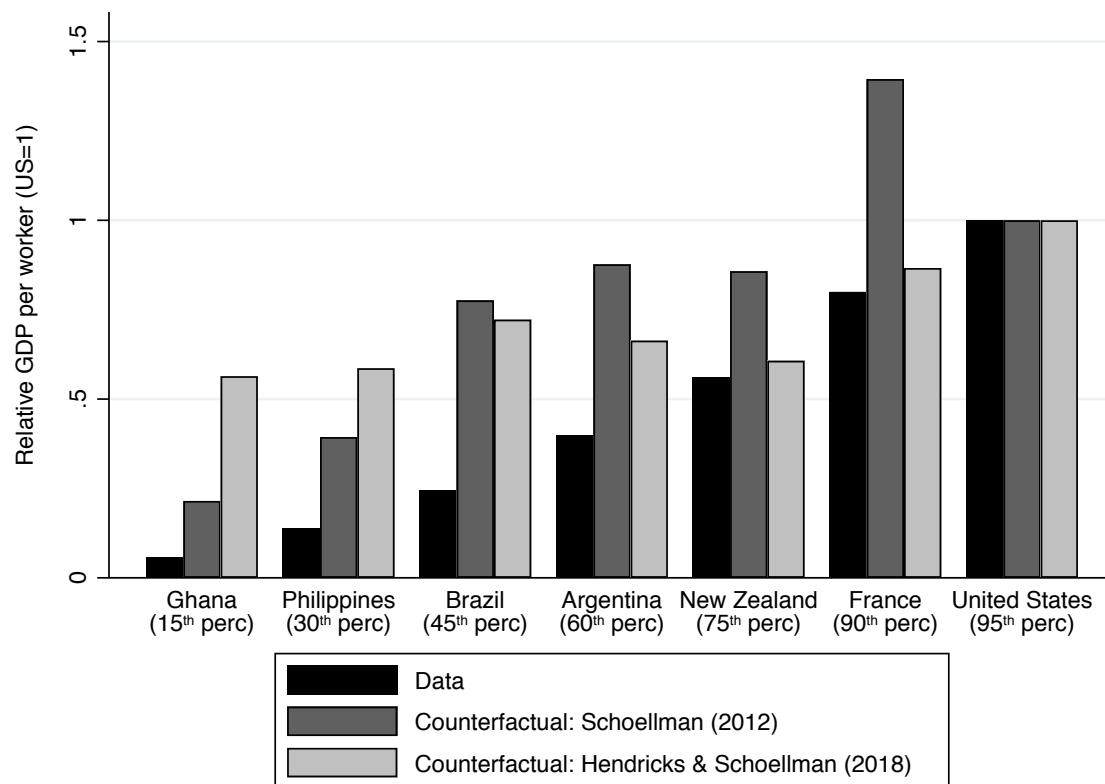
*Notes:* The figure plots the actual value (black bars) and various counterfactuals for GDP per worker (in PPP terms) in 2010, relative to the United States. The dark grey bars correspond to the counterfactual values when all countries are assigned the average level of educational attainment as in the United States. The light grey and white bars correspond respectively to the counterfactual values when, in addition to educational attainment, all countries are assigned either the average level of cognitive skills (as measured by test scores) or health status (as measured by the survival rate to age 65) as in the United States. GDP per worker is taken from version 9.0 of the Penn World Tables (Feenstra et al., 2015), educational attainment from Barro and Lee (2013), average test scores from Hanushek and Woessmann (2012a) and Hanushek and Woessmann (2012b), and the survival rate is computed from the World Development Indicators (World Bank, 2019).

Figure 5: Development Accounting: Experience



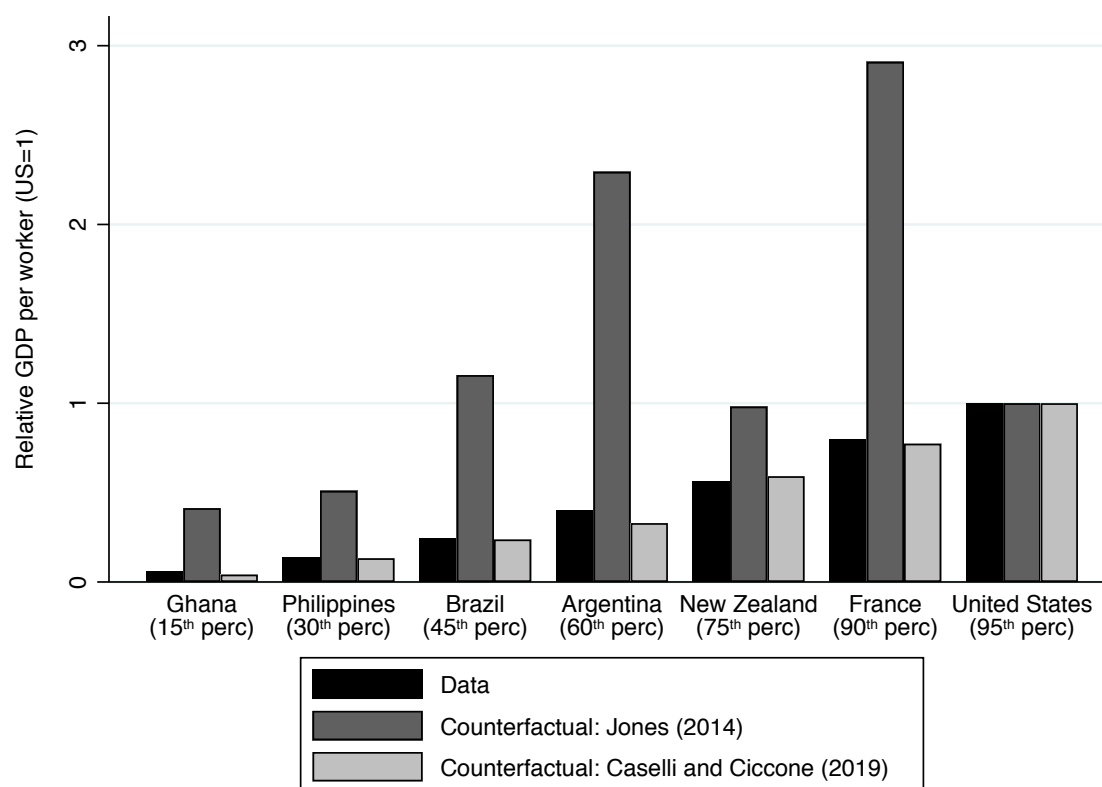
*Notes:* The figure plots the actual value (black bars) and various counterfactuals for GDP per worker (in PPP terms) in 2010, relative to France. The dark grey bars correspond to the counterfactual values when all countries are assigned the average level of educational attainment as in France. The light grey bars correspond to the counterfactual values when, in addition to educational attainment, all countries are assigned returns to experience estimated for France. GDP per worker is taken from version 9.0 of the Penn World Tables (Feenstra et al., 2015), educational attainment from Barro and Lee (2013), and returns to experience from Lagakos et al. (2018a).

Figure 6: Development Accounting based on Migrant Data



*Notes:* The figure plots the actual value (black bars) and various counterfactuals for GDP per worker (in PPP terms) in 2010, relative to the United States. The dark grey and light grey bars correspond to the counterfactual values when all countries are assigned the average level of human capital as in the United States, based on the estimates in Schoellman (2012) (dark grey) and Hendricks and Schoellman (2018) (light grey). GDP per worker is taken from version 9.0 of the Penn World Tables (Feenstra et al., 2015).

Figure 7: Development Accounting with Imperfect Substitutability



*Notes:* The figure plots the actual value (black bars) and various counterfactuals for GDP per worker in 2010, relative to the United States. The dark grey and light grey bars correspond to the counterfactual values under imperfect substitutability between skilled and unskilled. For the dark grey bars, countries are assigned both the quantities and efficiencies of skilled and unskilled labor as in the United States, following Jones (2014). For the light grey bars, countries are assigned only the quantities of skilled and unskilled labor as in the United States, following Caselli and Ciccone (2019). GDP per worker is taken from version 9.0 of the Penn World Tables (Feenstra et al., 2015), while the shares of skilled and unskilled labor are computed from Barro and Lee (2013).